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# Stanislaus River Temperature Monitoring/Modeling Project

**Annual Report 2001**

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## Background

Analysis of the effects of water temperature on the anadromous fish population in the Stanislaus River was directed by Congress in the legislation authorizing the construction of New Melones Dam and Reservoir. In addition, the Central Valley Project Improvement Act (CVPIA), Public Law 102-575, Title XXXIV, Section 3406 (c)(2) and Section (e)(1) directs the Secretary to investigate "measures to maintain suitable temperatures for anadromous fish survival in the Sacramento and San Joaquin Rivers and their tributaries." This, and the documented presence of potentially lethal water temperatures in the lower Stanislaus River below Goodwin Dam in key spawning and rearing habitats for fall-run chinook salmon and steelhead rainbow trout led the California Department of Fish and Game (CDFG), U.S. Bureau of Reclamation (USBR), U.S. Fish and Wildlife Service (USFWS), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), and Stockton East Water District (SEWD) in 1998 to jointly fund development of the Lower Stanislaus River Basin HEC5Q Water Temperature Computer Simulation Model.

When reviewing the water temperature data that had been collected to date for the lower Stanislaus River below Goodwin Dam, the Goodwin, Tulloch, and New Melones Reservoir Complex, as well as inflows into New Melones, it became evident that more extensive water temperature data would be necessary to both calibrate the Lower Stanislaus River Basin HEC5Q Water Temperature Computer Simulation Model, and be able to improve the model's predictive capability over time. Therefore, the USBR funded the CDFG to collect water temperature data in the lower Stanislaus River from Goodwin Dam to the confluence with the San Joaquin River; the Goodwin, Tulloch, and

New Melones Reservoirs; and in the North, South, and Middle Forks of the Stanislaus River immediately upstream of New Melones Reservoir. This report documents the water temperature collection effort by the CDFG in the Stanislaus Basin for the years 1999 through 2001.

**Purpose**

The "Stanislaus River Temperature Monitoring/Modeling Project" is designed to develop a computer simulation model capable of simulating water operations, both river flows and reservoir storage, and then predicting water temperature response and other related water quality data in the New Melones reservoir complex and in the lower Stanislaus River over a range of environmental conditions and flow regimes. To accomplish this, the water temperature data collection project has a threefold purpose: (1) To collect data necessary for calibration of the daily temperature model; (2) to identify locations along the river that would be appropriate for permanent monitoring stations; and (3) develop fall-run chinook salmon and steelhead rainbow trout temperature tolerance criteria to evaluate differences in temperature benefits between water operational scenarios.

Data collected from this project are essential to the development of a long-term operating plan for New Melones and Tulloch Reservoirs, and will benefit water operators in their efforts to improve water temperature conditions for fall-run chinook salmon and steelhead rainbow trout in the lower Stanislaus River. Data collected by this project in combination with development of the computer simulation model will allow the Stanislaus River stakeholders to analyze the relation between releases from New Melones and Tulloch Reservoirs and water temperatures in the Stanislaus River. Results from the model runs will provide the basis for further analysis of the relationship between operations, water temperature variation, and fish mortality in the Stanislaus River.

**Temperature Monitoring**

In June 1999, CDFG deployed 14 Optic StowAway temperature loggers on the Stanislaus River. Seven of these thermographs were placed at various locations between Goodwin Dam and the confluence with the San Joaquin River. Two thermographs were placed to monitor Tulloch release temperatures into Goodwin Pool. One thermograph was placed in the upper end of Tulloch Reservoir to monitor Melones Reservoir release temperatures into Tulloch Reservoir. The other four thermographs were placed above New Melones Reservoir to monitor inflow temperatures to New Melones Reservoir. All of these thermographs have been set to take temperature readings every 2 hours. CDFG is responsible for maintaining the units, and both retrieving and managing the data.

An example of the utility of the data collected is provided in figures 1 and 2, which compare water flow, as measured at Orange Blossom versus water temperature response, as measured at Oakdale Recreation area for the years 1999-2000 (Figure 1) and 2000-2001 (Figure 2). The thermographs are downloaded on a monthly basis, and the

data can be retrieved from the CDEC website (http://cdec.water.ca.gov/cgi-progs/selectQuery). The following are the station codes and descriptions:

CLP- Collierville Powerhouse tailrace (COLL)
GDC- Goodwin Canyon immediately downstream of Goodwin Dam (GOOD)
GMB- Gambini property immediately downstream of the pond at Oakdale Recreation Area(GMB)
JMP- Riverbank (Downstream end of Jacob Meyers Park) (RB)
KFS- Knights Ferry at the Sonora Road Bridge (KF)
NMT- New Melones Powerhouse tailrace (NMPH)
OBS- 1/4 mile downstream of Orange Blossom Bridge (OB)
ORA- Oakdale Recreation Area (1/4 mile downstream of Hwy 120 Bridge) (OAKR)
SBC- Approx. 1/4 mile upstream of the confluence with the San Joaquin River (SS)
SSC- Stanislaus Powerhouse (In the Stanislaus canal immediately upstream of the forebay)(SPHF)
SSF- South Fork of the Stanislaus approximately 2 miles upstream of New Melones (SF)
TCN- Below the confluence of the North and Middle Forks upstream of the Collierville (NFMF) Powerhouse
TDP- Tulloch Powerhouse tailrace (TULT)
TDS- Tulloch Dam spillway (TULS)

Additionally, bi-weekly temperature profiles are taken on New Melones and Tulloch Reservoirs. Profiles are taken at seven different locations at New Melones, and two locations at Tulloch. Since June of 1999, a total of 50 days have been profiled on Melones and a total of 40 days have been profiled on Tulloch. Figures 3-6 show the seasonal variation of the water temperature profile in front of New Melones Dam. Figures 7-9 show the seasonal variation in front of Tulloch Dam. Historically, data records for reservoir temperature profiles extend back to 1963. However, prior to 1999 water temperature profiles were not collected on a consistent basis.

During the summer of 2000, CDFG conducted a special study on Goodwin Pool. The purpose of this study, funded by Oakdale Irrigation District, was to find out how much warming occurs as the water flows between Tulloch and Goodwin Dams. CDFG took temperature profiles at three locations on Goodwin Reservoir on a bi-weekly basis. A string of three thermographs was placed near the face of Goodwin Dam, in order to record a continuous profile. Figure 10 shows the average daily temperatures on Goodwin Pool. Thermographs were also placed in the Oakdale and South San Joaquin Irrigation canals, as well as the intake to the Stockton East Water District tunnel. This study was also repeated in 2001.

Both the thermograph and reservoir profile data are stored in an Access database, which was designed by AD Consultants, and funded by the USBR. CDFG is responsible for maintaining and keeping the database up to date. The temperature database has a data quality assurance and quality control utility built into it, so any errors are corrected at the time that the data is transferred into the database. The database also has some report and graph options, which allows data collected at 2 or more sites to be simultaneously compared graphically. Figures 11 and 12 were produced using this graphing option; they compare the water temperatures between Goodwin Canyon and the confluence with the San Joaquin River.

Five weather stations, purchased by the lower Stanislaus River principle stakeholders, have been installed along the Stanislaus River. These have been operational since August 2000. These stations are located at Beardsley Powerhouse, New Melones Reservoir, Goodwin Reservoir, Oakdale, and Ripon. These weather stations record temperature, wind speed and direction, relative humidity, and solar radiation. The data from the weather stations is currently downloaded every three months. There is a possibility that the stations will be telemetered in the future so that the information can be transferred directly to the internet. Having five weather stations allows us to capture the spatial variations in meteorology along the river, which will lead to a more accurate and reliable water temperature model. The original Stanislaus River Basin HEC5Q Water Temperature Model was calibrated using meteorological data measured at a meteorological station located west of Modesto. It is anticipated that the model's water temperature prediction capability will improve with use of a localized data source. Table 1 shows a monthly summary of the weather data that was collected at the Goodwin Reservoir site for April 2001.

**Temperature Modeling**

AD Consultants has the responsibility of developing a functional computer model to simulate temperatures in the Stanislaus River. The water quality component of the U.S. Army Corps of Engineers, Hydrologic Engineering Center computer model HEC-5Q, Simulation of Flood Control and Conservation Systems, was adapted to the river-reservoir system. This model is now capable of modeling water temperature regimes in New Melones Reservoir, Tulloch Reservoir, Goodwin pool, and at defined control points on the Stanislaus River between Goodwin Dam and the confluence with the San Joaquin River.

The model allows the user to analyze the relationship between flow releases from New Melones and Tulloch and water temperature response in the Stanislaus River. It also allows the user to look at various operational plans for New Melones and Tulloch reservoirs and the effects of these plans on downstream temperatures. Results from the model runs will provide the basis for further analysis of the relationship between reservoir operations, water temperature variation, and fish mortality in the Stanislaus River.

The cost-sharing partners have agreed upon eleven different operation scenarios that have been used to make the initial model runs. These initial runs have been completed, and were analyzed based on a set of objectives derived from the *Stanislaus River Temperature Monitoring/Modeling Project Water Temperature Criteria* (CDFG, 2001) (Appendix A). In March 2002, the temperature model was completed and a final version of the model was delivered to each one of the cost-sharing partners. They have been trained in using the model so that they can perform their own analysis.

**Temperature Suitability**

The temperature objectives that were used to analyze the temperature model identified three zones of water temperature conditions: optimal, sub-lethal, and critical. The objectives also identified locations where the temperature conditions should be met at different times of the year in order to protect all life stages of salmon and steelhead (Table 2).

Table 2. Water Temperature Objectives

| | **Salmon** | | | | **Steelhead** |
|---|---|---|---|---|---|
| | **Oct-Feb** | **Mar-Jun** | **July-Aug** | **Sept** | **Oct-Sept** |
| Temperature Criteria Location | Riverbank (RB) RM 33 | Confluence (CON) RM 0.5 | Knights Ferry (KF) RM 54 | Confluence (CON) RM 0.5 | Oakdale (OAK) RM 40 |
| Optimal-Max (˚C) | 12.2 | 12.8 | 15.6 | 12.2 | 11.1 |
| Sub-Lethal (˚C) | 12.2-16.7 | 12.8-18.3 | 15.6-18.3 | 12.2-18.3 | 11.1-13.3 |
| Critical (˚C) | 16.7 | 18.3 | 18.3 | 18.3 | 13.3 |

In order to characterize the general suitability of water temperatures for chinook and steelhead, the actually daily maximum temperatures was compared with the water temperature objectives. Tables 3 and 4 show the frequency with which the optimal-max and critical temperatures were exceeded for salmon and steelhead respectively.

Table 3. Salmon Temperature Criteria Exceedance

| | **(1999-2000)** | | | | **(2000-2001)** | | | |
|---|---|---|---|---|---|---|---|---|
| Period | Oct-Feb | Mar-Jun | July-Aug | Sept | Oct-Feb | Mar-Jun | July-Aug | Sept |
| Temp. Criteria Location | RB | CON | KF | CON | RB | CON | KF | CON |
| Total Days in Period | 151 | 123 | 61 | 30 | 151 | 123 | 61 | 30 |
| # Days sub-lethal | 56 | 73 | 50 | 0 | 32 | 61 | 61 | 0 |
| # Days critical | 0 | 18 | 0 | 30 | 8 | 55 | 0 | 30 |
| % Days sub-lethal | 37% | 59% | 82% | 0% | 21% | 50% | 100% | 0% |
| % Days critical | 0% | 15% | 0% | 100% | 5% | 45% | 0% | 100% |

Table 4. Steelhead Temperature Exceedance

| | **1999-2000** | **2000-2001** |
|---|---|---|
| Period | Oct-Sept | Oct-Sept |
| Temp Criteria Location | OAK | OAK |
| Total Days in Period | 365 | 365 |
| # Days sub-lethal | 109 | 67 |
| # Days critical | 201 | 232 |
| % Days sub-lethal | 29.86% | 18.36% |
| % Days critical | 55.07% | 63.56% |

**Future Plans**

The California Department of Fish and Game recently signed a contract with the U.S. Bureau of Reclamation, which will extend funding for the project through December 2002. This will allow CDFG to continue monitoring water temperature on the Stanislaus system, as well as collecting data from the five weather stations. Sufficient flow and temperature data are necessary for both simulation and validation of the temperature model. It is important to continue this monitoring program so that water temperature response to varying river flow and reservoir operations can be observed.

AD Consultants, with the support of the cost-sharing partners, submitted a CALFED proposal to continue river temperature work on the Stanislaus and Lower San Joaquin Rivers (Stanislaus- Lower San Joaquin River Water Temperature Modeling and Analysis). This proposal was recently approved for funding, and will allow work to continue beyond 2002 when the current contract expires. The objectives of this proposal are:

1. Extend the existing model to downstream San Joaquin River reaches to create a Stanislaus-San Joaquin River (S-SJR) Water Temperature Model.
2. Refine the S-SJR Water Temperature Model using current water temperature and meteorological data.
3. Perform operational studies to enhance water temperature conditions on the Stanislaus River.
4. Perform pre-feasibility studies of alternative actions.
5. Develop implementation plans for alternative that provide effective, feasible, and acceptable improvements in water temperature control.
6. Collect, store, and manage water temperature and meteorological data.
7. Assemble a peer review panel to evaluate the biological merits, and application to the Stanislaus River, of the CDFG water temperature tolerance criteria for Central Valley fall-run chinook salmon and steelhead (Appendix A).

**Figure 1**
**Water Year 1999-2000**

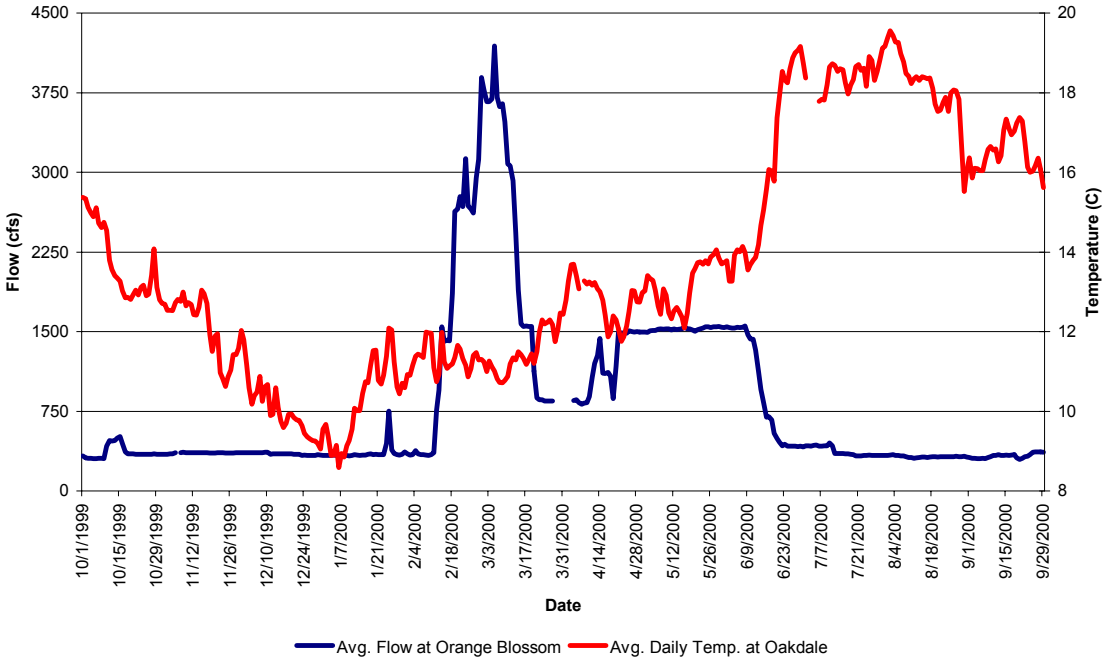


**Figure 2**
**Water Year 2000-2001**

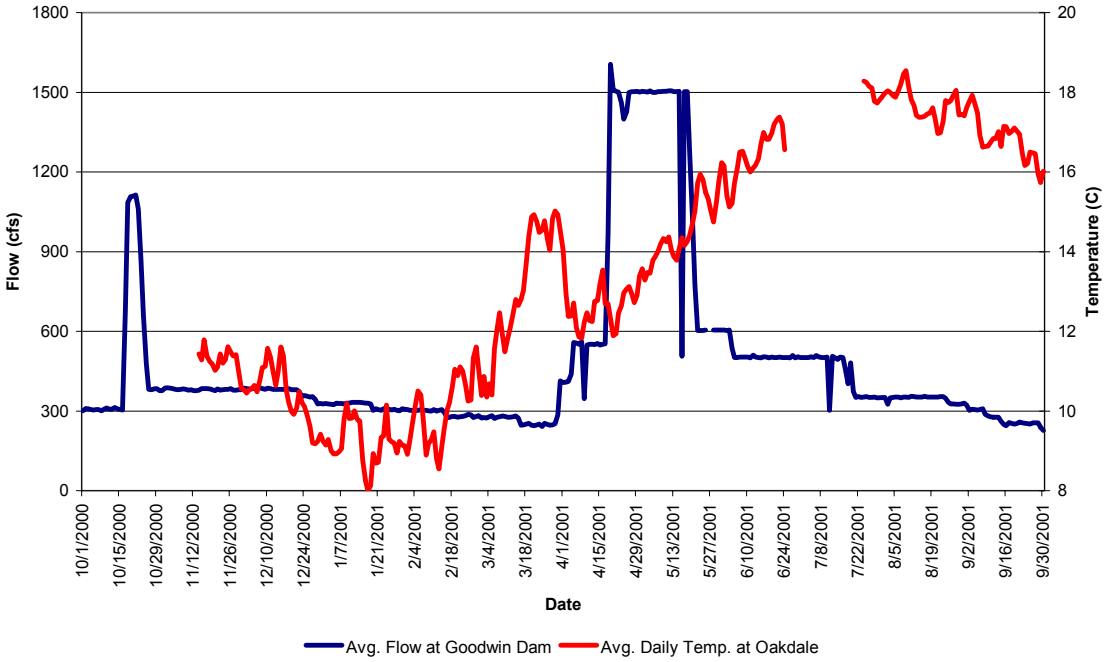

**Figure 3**
**New Melones (9/1/99)**

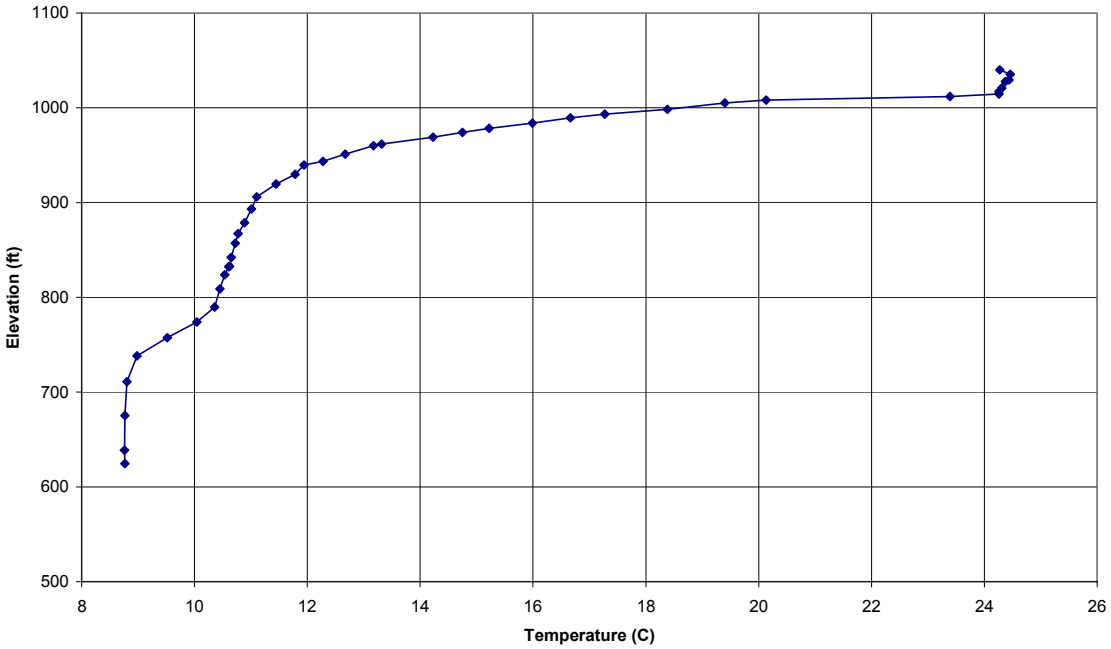


**Figure 4**
**New Melones (12/6/99)**

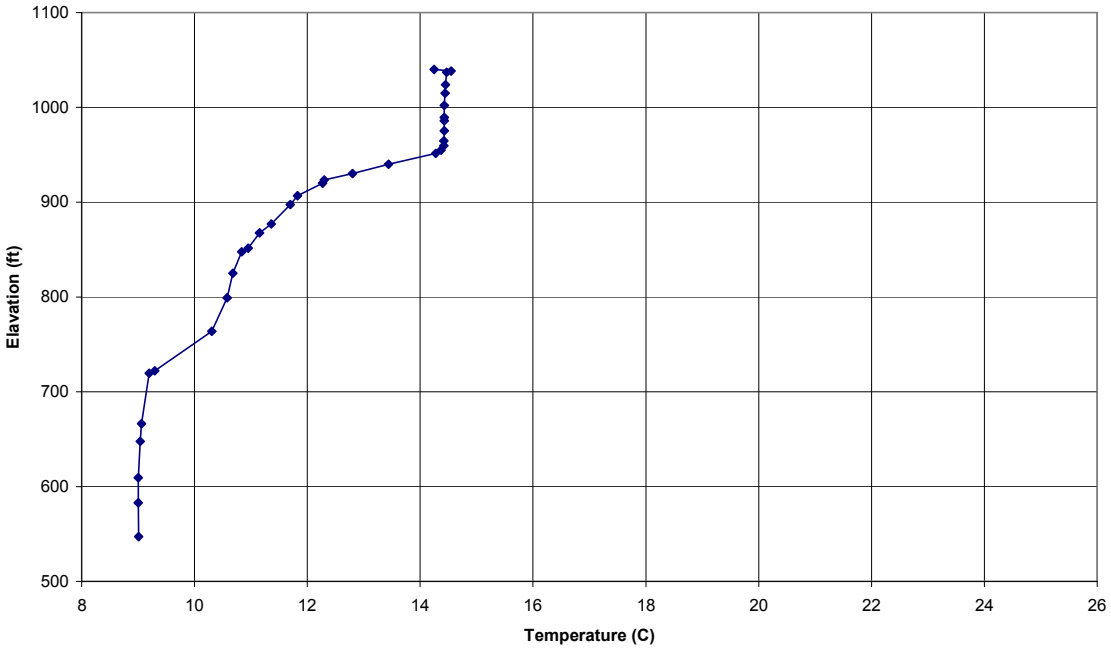

**Figure 5**
**New Melones (3/27/00)**

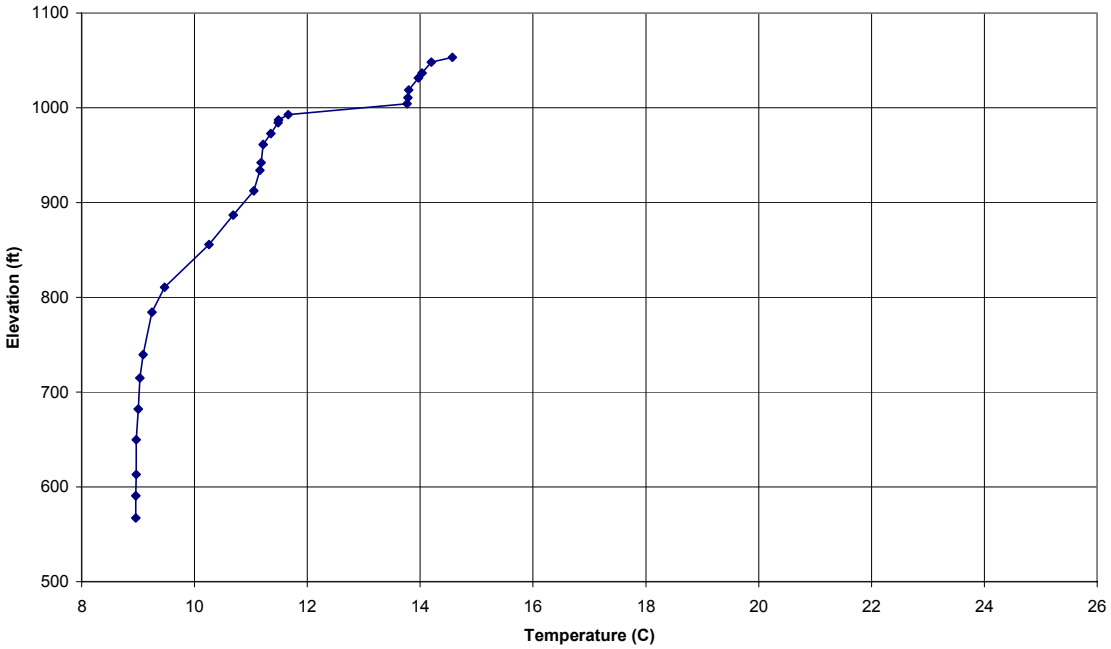


**Figure 6**
**New Melones (6/7/00)**

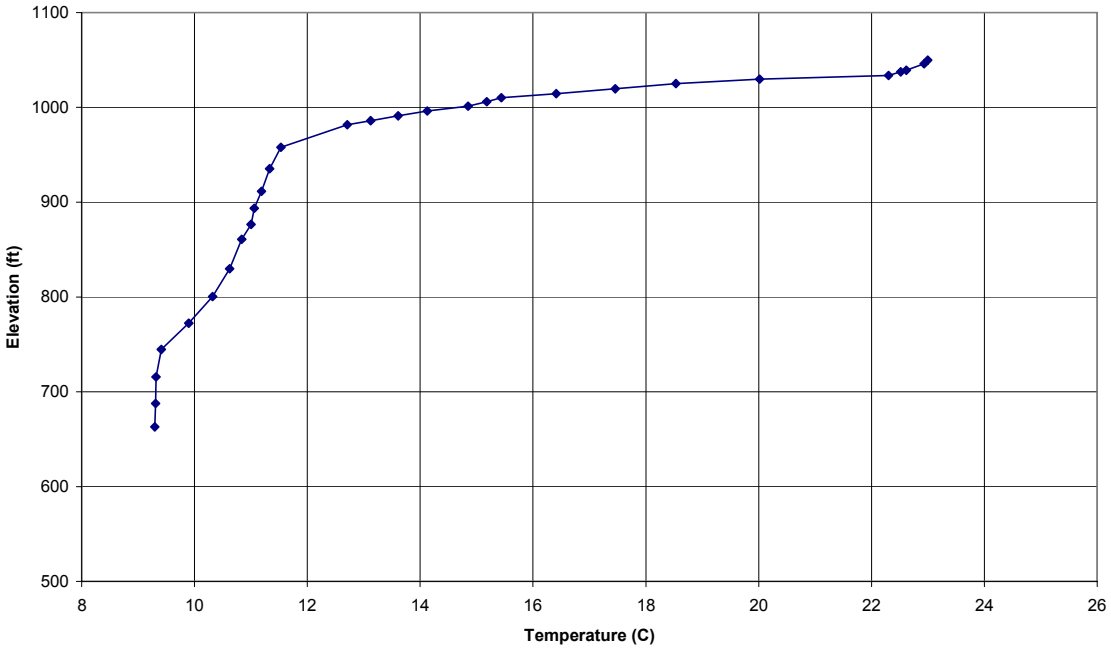

**Figure 7**
**Tulloch (9/1/99)**

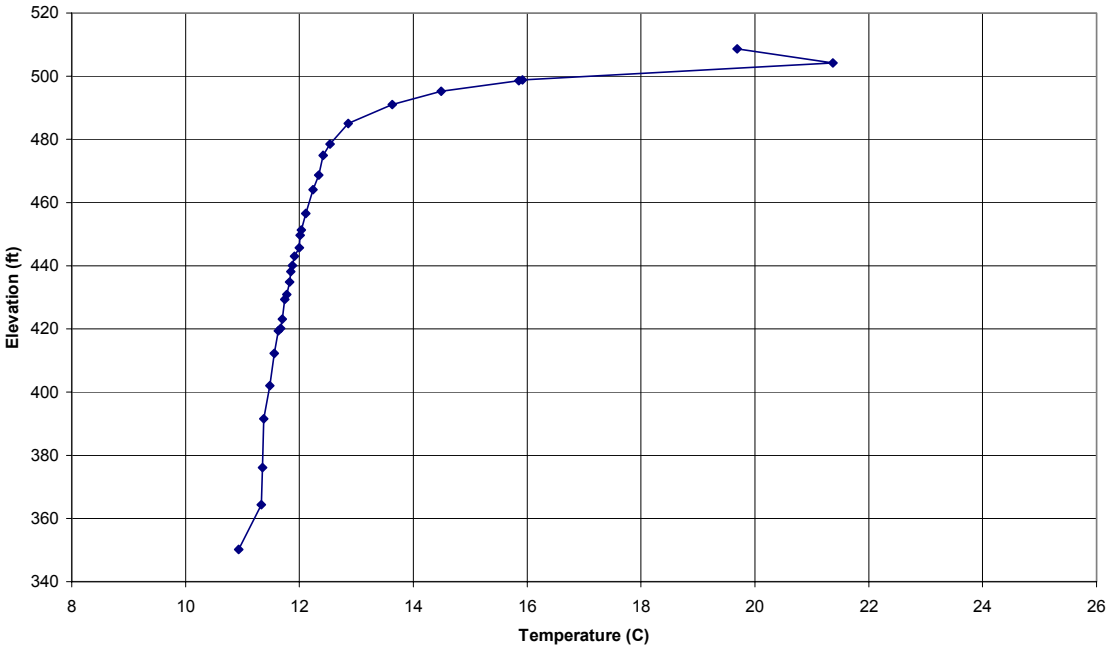


**Figure 8**
**Tulloch (12/6/99)**

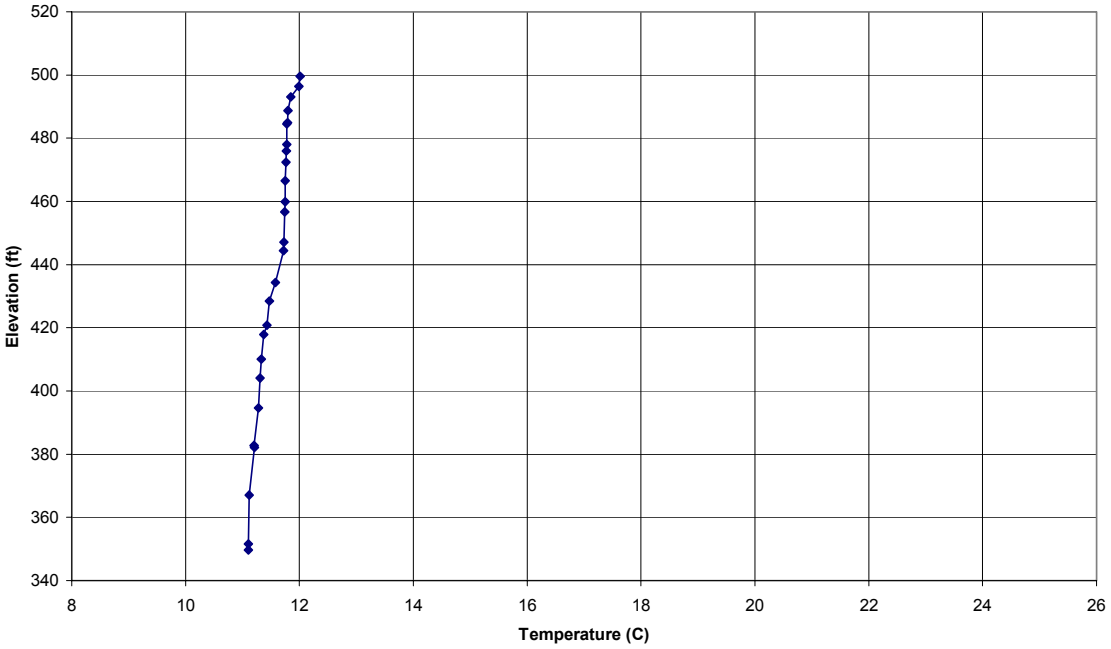

**Figure 9**
**Tulloch (6/7/00)**

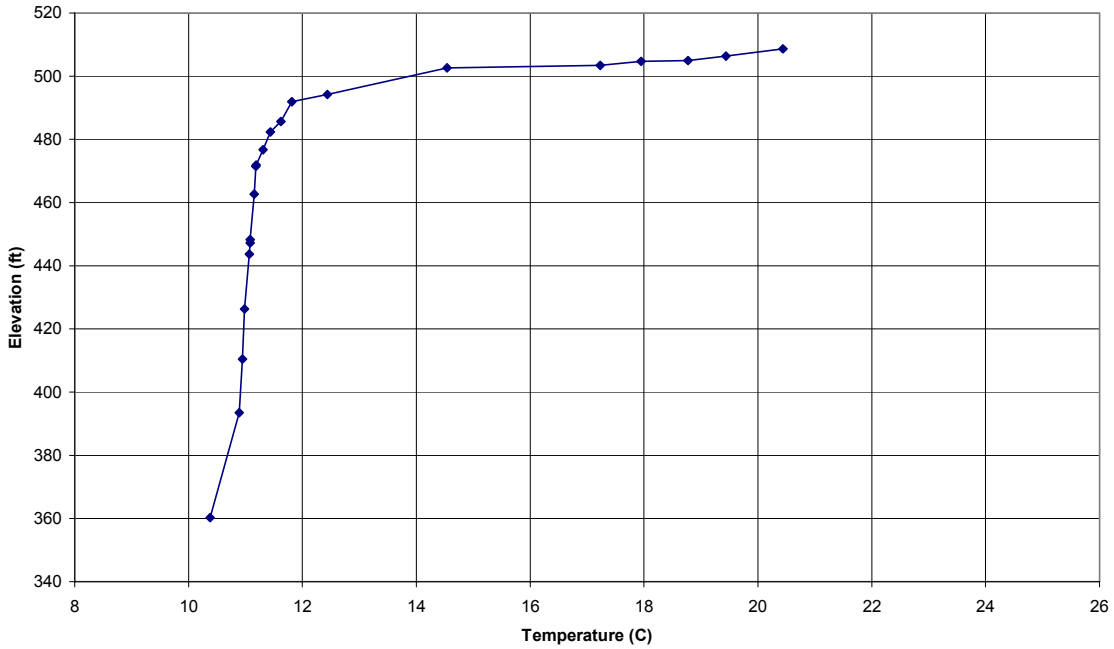


**Figure 10**
**Goodwin Pool**